Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of Amendment of Section 15.255 of the Commission's Rules	ET Docket No. 21-264

COMMENTS OF GOOGLE LLC

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Google applauds the Commission for initiating this rulemaking[1] to promote long-term development and certainty in the 57-71 GHz band (60 GHz band).

INTRODUCTION AND SUMMARY

The commercial promise of the 60 GHz band has long been discussed. Within the past five years, however, the Commission's *Spectrum Frontiers Order*[2] and *Soli Waiver Order*[3] have unleashed a wave of innovation in low-power 60 GHz radar technologies with immediate impact for consumers. Radar technologies in the 60 GHz band have been approved for gesture control, detection of unattended children or pets in vehicles, sleep assessment, and monitoring of vulnerable medical patients, with some products already available and new products and services on the horizon in the areas of personal safety, autonomous vehicles, home automation, environmental control, and

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[1] *In the Matter of Amendment of Section 15.255 of the Comm'n's Rules*, Notice of Proposed Rulemaking, ET Docket No. 21-264, FCC 21-83 (rel. July 14, 2021) (*NPRM*).
[2] *See In the Matter of Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al.,* Report and Order and Further Notice of Proposed Rulemaking, 31 FCC Rcd. 8014 (2016) *(Spectrum Frontiers Order)*.
[3] *In the Matter of Google LLC Request for Waiver of Section 15.255(c)(3) of the Comm'n's Rules Applicable to Radars Used for Short-Range Interactive Motion Sensing in the 57-64 GHz Frequency Band*, Order, 33 FCC Rcd. 12542 (2018) (*Soli Waiver Order*).

additional healthcare monitoring, to name a few. The time is right for the Commission to sustain and even accelerate this progress by updating its Part 15 rules.

Google generally supports the approach proposed in the *NPRM*, which would foster reasonable coexistence across unlicensed communications and radar technologies using 60 GHz frequencies. In particular, updated rules should eliminate constraints on short-range devices for interactive motion sensing (SRIMS), which have proven unnecessarily restrictive and accordingly generated an onslaught of petitions for regulatory waiver to operate at higher power levels. Low-power radars subject to Commission waivers have in fact operated in the 60 GHz band since late 2019 with no reports of interference. Updates to the Commission's rules would ensure continued coexistence among these devices, as well as current and future unlicensed communications devices in the 60 GHz band.

Expeditious action to modernize permissible 60 GHz operating parameters would foster important public interest benefits including: development of transformational—and even life-saving—technologies; advancement of American leadership in wireless innovation; and promotion of global regulatory harmonization. While making these changes, however, the Commission should ensure that low-power 60 GHz radars currently in use continue to fulfill user expectations by retaining its rule for narrow bandwidth fixed field disturbance sensors (FDS) operating between 61.0-61.5 GHz, and by grandfathering the specific technologies currently authorized via regulatory waiver.

I. THE 60 GHZ BAND HAS CHARACTERISTICS IDEAL FOR VALUABLE RADAR TECHNOLOGIES.

In the handful of years since the *Spectrum Frontiers Order* reversed the Commission's ban on mobile field disturbance sensors (MFDS) (including the class of mobile radars) in the 60 GHz band,[4] innovators have shown growing and widespread interest in making technologies powered by radars available to Americans. Numerous industry stakeholders have released or are in the process of launching radar-based technologies that, for example, allow for health and wellness monitoring, detect children or pets left behind in vehicles, and increase device accessibility and usability for users with disabilities. The Commission now has an opportunity to sustain and accelerate this momentum by updating its rules to promote long-term certainty, create flexibility necessary for innovation, meet consumer expectations, and ensure reasonable coexistence among unlicensed technologies using 60 GHz frequencies.

A. Reversal of the Ban on 60 GHz MFDS Has Enabled Important Innovations In Service of the Public Interest.

Five years ago, the Commission lifted a decades-long ban on the use of MFDS in the 60 GHz band after requests by Google and the Consumer Technology Association were unopposed on the record.[5] This singular action accelerated intensive development of unlicensed radar technologies. The 60 GHz band's characteristics, which are ideal for radar applications, facilitated innovation. Ample available bandwidth enables fine spatial recognition, and the propagation characteristics at 60 GHz[6] naturally limit coverage to

[4] *See Spectrum Frontiers Order* ¶ 337.
[5] *Id.* ¶¶ 335-337.
[6] Spectrum in the 60GHz band exhibits significantly higher free-space path loss (FSPL) than lower frequency bands due to the Friis equation's frequency-squared relationship (e.g., FSPL is 21.5 dB higher (at any distance) at 60 GHz versus at 5 GHz). *See Friis transmission equation*,

line-of-sight or to near-line-of-sight, thus helping low-power radar sensors to accurately sense nearby activity and limiting in-band interference.

For example, Google's Motion Sense technology enabled by Project Soli sensors operates in the 60 GHz band to capture three-dimensional motion in the immediate proximity of the device, using a radar beam. Data collected by the sensor can enable touchless control of device functions or features. As the Commission has noted, the "ability to recognize users' touchless hand gestures to control a device, such as a smartphone, could help people with mobility, speech, or tactile impairments, which in turn could lead to higher productivity and quality of life for many members of the American public."[7]

The power levels adopted in the 2016 *Spectrum Frontiers Order* and set forth in Rule 15.255(c)(3) ensure that radars "operate at very short distances" to "minimize their harmful interference potential."[8] But the power levels are too restrictive to adequately enable the types of activity expressly intended by the Commission. In particular, studies conducted by Google found that operation of Soli sensors pursuant to power levels in Rule 15.255(c)(3) constrains gesture-based functionality to considerably shorter distances than what users desire or expect.[9] This led Google in March 2018 to seek a

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https://en.wikipedia.org/wiki/Friis_transmission_equation (last visited Sept. 20, 2021). 60 GHz spectrum also exhibits high attenuation through objects such as drywall. *See e.g.*, Xu, *et al.,* *Spatial and Temporal Characteristics of 60-GHz Indoor Channels,* IEEE Journal on Selected Areas in Communications, 623 (Apr. 2002), *available at* https://www.researchgate.net/publication/3234787_Spatial_and_temporal_characteristics_of_60-GHz_indoor_channels.

[7] *Soli Waiver Order* ¶ 12.

[8] *Spectrum Frontiers Order* ¶ 337; 47 C.F.R. § 15.255(c)(3).

[9] Google has produced several analyses of Soli gesture recognition accuracy under different regulatory transmission power limits. *See, e.g.,* Jian Wang & Jaime Lien, *Gesture Classification Performance Estimate Under Regulatory Limits* (Oct. 2018), included as Attachment A; Jian Wang & Jaime Lien, *Gesture Classification Performance Estimate Under Regulatory Limits* (Feb. 2019), included as Attachment B.

waiver of power levels in Commission Rule 15.255(c)(3).[10] Specifically, Google sought to operate Soli sensors between 57 and 64 GHz at levels harmonized to ETSI standard EN 305 550 (i.e., mean conducted power of +10 dBm, mean power spectral density (PSD) EIRP of +13 dBm/MHz, and mean EIRP of +20dBm).[11]

Following industry negotiations over that request, the December 2018 *Soli Waiver Order* allowed Soli sensors to operate at power levels negotiated and proposed jointly by Google and Facebook[12] and supported on the record by Qualcomm.[13] Specifically, Google can increase Soli sensors' peak transmitter conducted output power from -10dBm to +10dBm and peak EIRP from +10dBm to +13dBm with maximum 10% duty cycle for 57-64 GHz interactive motion sensing applications.[14] Within a year of receiving permission through the *Soli Waiver Order*, Google commercially launched radar-enabled products using Motion Sense technology. To date, Google devices using 60 GHz radars include Pixel 4/4XL smartphones (launched

[10] Google LLC Request for Waiver of Section 15.255(c)(3) the Comm'n's Rules (filed Mar. 7, 2018) (*Soli Waiver Order*).
[11] *See* ETSI, *Short Range Devices (SRD); Radio Equipment to be Used in the 40 GHz to 246 GHz Frequency Range; Harmonised Standard for Access to Radio Spectrum,* Draft EN 305 550 V2.1.0 (Oct. 2017) at 14, 15 (Tables 3 and 4), at https://www.etsi.org/deliver/etsi_en/305500_305599/305550/02.01.00_20/en_305550v020100a.pdf.
[12] *See* Letter from Megan Anne Stull, Counsel, Google LLC, and Pankaj Venugopal, Assoc. Gen. Counsel, Facebook, Inc., to Marlene H. Dortch, Sec'y, FCC, in ET Docket No. 18-70 at 1-2 (filed Sept. 7, 2018) (stating that Facebook agrees "that Project Soli sensors could operate within the [*Soli Waiver Order* conditions] without causing levels of interference that Facebook's previous filings characterized as unreasonable").
[13] *See* Letter from John W. Kuzin, Vice President and Regulatory Counsel, Qualcomm Inc., to Marlene Dortch, Sec'y, FCC, in ET Docket 18-70 (filed Nov. 16, 2018) (asserting that Qualcomm "fully supports the FCC approving the [Soli] waiver according to the terms presented in the joint filing by Facebook and Google").
[14] *Soli Waiver Order* ¶ 14.

in October 2019); Nest Thermostats (launched in October 2020);[15] and the second-generation Nest Hub (released in March 2021).

Google is not alone in its enthusiasm for products containing low-power 60 GHz radars. Interest from a variety of industry stakeholders has been widespread, significant, and sustained. For instance, the Commission recently granted multiple waivers of its Rule 15.255 power levels and use designations to enable innovative and, in some cases potentially life-saving, radar technologies.[16] Current and anticipated radar use cases extend to detection of children or pets left behind in vehicles, health and wellness monitoring, and enhancements to device accessibility and usability. The high level of activity in development of 60 GHz low-power radars stands in contrast to the very

[15] Nest Thermostat complies with spectrum rules for fixed devices using 61.0-61.5 GHz frequencies. *See* 47 C.F.R. § 15.255(c)(2).

[16] *See Petition of Faurecia Clarion Elec. N. Am. Regarding 47 C.F.R. § 15.255*, Letter Order, DA 21-811 at 4 (rel July 9, 2021) (waiver to "provide potentially lifesaving applications — in this case, radars deployed in passenger motor vehicles to detect children left unattended in hot cars"); *Request by Texas Instruments Inc. for Waiver of 47 C.F.R. § 15.255(c)(3)*, Letter Order, DA 21-812 at 4 (rel. July 9, 2021) (waiver for "radars deployed in passenger motor vehicles to detect children left unattended in hot cars"); *Request by Amazon.com Serv. LLC for Waiver of 47 C.F.R. § 15.255(c)(3)*, Letter Order, DA 21-813 at 1 (rel. July 9, 2021) (waiver to "enable touchless control of device features and functions[, including] . . . contactless sleep tracing functionalities"); *Request by Acconeer AB for Waiver of 47 C.F.R. § 15.255(c)(3) Rules*, Letter Order, DA 21-814 at 4 (rel. July 9, 2021) (waiver to "improv[e[passenger safety—most notably the prevention of vehicular pediatric heatstroke deaths"); *Request by Vayyar Imaging Ltd. for Waiver of 47 C.F.R. § 15.255 Rules*, Letter Order, DA 21-815 2, 4 (rel. July 9, 2021) (waiver for "radars used for medical and personal health purposes"); *Request by Huyndai Mobis Co., Ltd. for Waiver of 47 C.F.R. §§ 15.255(a)(2) & (c)(3)*, Letter Order, DA 21-816 at 4 (rel. July 9, 2021) (waiver for "radars deployed in passenger motor vehicles to detect children left unattended in hot cars"); *In the Matter of Vayyar Imaging Ltd. Request for Waiver of Section 15.255(c)(3) of the Comm'n's Rules for Radars Used for Interactive Motion Sensing in the Frequency Band 57-64 GHz, et al.*, Order, 36 FCC Rcd. 7218, ¶ 2 (2021) (waiver "to provide vehicular passenger safety and theft prevention applications when the radar is installed inside passenger motor vehicle cabins with the primary function to prevent risks of children inadvertently left unattended in a rear seat in hot weather"); *In the Matter of Leica Geosystems AG Request for Waiver of Section 15.255 of the Comm'n's Rules Applicable to Radars Used on Unmanned Aerial Vehicles in the 60-64 GHz Frequency Band*, Order, 35 FCC Rcd. 7929 ¶ 1 (2020) (waiver to "permit the certification and marketing" of a system to operate "aboard unmanned aircraft" and provide "visual inspection of structures").

limited use of the 60 GHz band by communications technologies such as Wi-Fi, despite the fact that the spectrum has been open to unlicensed communications uses for at least a decade.[17]

B. Operation of Low-Power Radars at Increased Power Levels Can Occur with No Threat to Reasonable Coexistence to Other Unlicensed Technologies in the 60 GHz Band.

Google products incorporating Soli chipsets have been available in markets around the globe since October 2019, and Google has received no reports of interference from those devices. The lack of interference is consistent with coexistence analyses conducted for Google prior to the launch of Motion Sense, which showed that Soli radar has little impact on WiGig (Wi-Fi in the 60 GHz band, i.e., IEEE 802.11ad) performance. Laboratory measurements of actual coexistence between a Soli radar and commercially available IEEE 802.11ad equipment at Commission Rule 15.255 and EN 305 550 power levels found that to cause significant harmful interference to an 802.11ad link, the radar would have to be positioned directly between the 802.11ad client and its associated access point, with the radar antenna transmitting from a position both extremely close to (i.e., within a few inches) and directly toward one of the 802.11ad antennas.[18] Indeed, the 802.11ad link was found to suffer more degradation

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[17] *See, e.g., So What Ever Happened to 60GHz 802.11ad WiFi?*, Poc Network, Jan. 9, 2021, https://www.pocnetwork.net/technology-news/so-what-ever-happened-to-60ghz-802-11ad-wifi/ (last visited Sept. 20, 2021); Info Depot Wiki, *List of 802.11ad Hardware*, http://en.techinfodepot.shoutwiki.com/wiki/List_of_802.11ad_Hardware (last visited Sept. 20, 2021).

[18] *See* Qi Jiang, et al., *Measurement Study on Soli/802.11ad Coexistence* (June 2018) at 1, included as Attachment C (finding that "[f]or a measurable effect to be seen, Soli must be positioned directly between the 802.11ad client and access point (AP), with the Soli antenna pointing directly into one of the 802.11ad antennas") (*Jiang et al.*); Gary Wong, et al., *Supplement to Measurement Study on Soli/802.11ad Coexistence* (Oct. 12, 2018) at 1 (showing that interference with a WiGig access point is "similar to or less than the levels of interference previously reported with the Soli device near the client."), included as Attachment D.

from a second 802.11ad link in close proximity than from a Soli sensor.[19] Simulations showed that the percentage of cases for which Wi-Fi throughput was degraded was small even in the worst-case scenarios (i.e., approximately 8% when assuming a 100% duty cycle for the radar), and negligible to non-existent in more realistic situations.[20]

Soli's minimal impact on WiGig is not surprising. To overcome the relatively high propagation loss experienced in the 60 GHz band, WiGig systems tend to be highly beamformed,[21] and thus WiGig receivers have a very limited field of view in which they meaningfully receive interference from a nearby radar device. Combined with the much lower EIRP of radar devices (versus the +43 dBm EIRP allowed for WiGig), this means that the scenarios in which Soli transmissions can be meaningfully received by a WiGig device are rare: the Soli device would need to be physically close to the WiGig device as well as oriented directly in the path of the WiGig beam.[22]

The opportunity for high spatial density of transmitters (i.e., numerous co-channel devices operating in close proximity) is a well-known benefit of general "millimeter wave" (30-300 GHz) systems. Per the Commission:

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[19] *See Jiang et. al.* at 16.
[20] The studies modeled Single Carrier modulation and coding schemes of 60 GHz Wi-Fi; accounted for a 60 GHz low-power radar's duty cycling on its interaction with Wi-Fi; provided calculations using a non-line-of-sight path loss channel model from the IEEE 802.11ad standard and a free space line-of-sight channel model; and examined outlier scenarios such as when a 60 GHz radar and Wi-Fi station would be positioned in extremely close proximity. *See* Dr. Stefan Mangold, *Assessing the Interference of Miniature Radar on Millimeter Wave 60 GHz Wi-Fi: Simulation Study* (Feb. 21, 2018), included as Attachment E (*Mangold Feb. 2018 Study*); Dr. Stefan Mangold, *Assessing the Interference of Miniature Radar on Millimeter Wave 60 GHz Wi-Fi — Supplemental Analysis* (June 8, 2018), included as Attachment F (*Mangold June 2018 Study*).
[21] *See* MathWorks, *802.11ad Waveform Generation with Beamforming*, https://ww2.mathworks.cn/help/wlan/ug/802-11ad-waveform-generation-with-beamforming.html (last visited Sept. 20, 2021) (explaining that to "overcome the large path loss experienced at 60 GHz, the IEEE 802.11ad standard is designed to support directional beamforming").
[22] *See Jiang et al.*, at 1.

> At these frequencies, radio signals attenuate more rapidly with distance than at other frequencies and antennas that can narrowly focus transmitted energy are practical and of modest size. While the limited range of such transmissions might appear to be a major disadvantage for many applications, it does allow the reuse of frequencies within very short distances and, thereby enables a higher concentration of transmitters to be located in a geographical area than is possible at lower frequencies.[23]

Indeed, WiGig proponents have touted the ability for many devices to operate co-channel as a critical characteristic of the 60 GHz band.[24]

Data recently provided by Infineon Technologies Americas Corp. (Infineon) confirm Google's studies of radar/WiGig coexistence.[25] Infineon took co-channel compatibility measurements of "60 GHz radars and WiGig devices in a variety of configurations, including worst-case configurations and operating parameters."[26] Its tests revealed that "minor losses in data rates for WiGig devices" have the possibility of occurring "only in limited configurations where there is a device separation of 40 cm or less and the radar and communications devices are configured along the same bore-sight and in the same polarization plane."[27] As Infineon explained, the range of potential WiGig applications in the 60 GHz band makes the "likelihood of a 60 GHz

[23] FCC, *Millimeter Wave 70/80/90 GHz Service*, at https://www.fcc.gov/millimeter-wave-708090-ghz-service (last visited Sept. 20, 2021).
[24] *See* Thomas Nitsche, *et al.*, *IEEE 802.11ad: Directional 60 GHz Communication for Multi-Gigabit-per-Second Wi-Fi*, IEEE COMMUNICATIONS MAGAZINE, 132-134 (Dec. 2014), https://www.researchgate.net/profile/Adriana-Flores-9/publication/273392463_IEEE_80211ad_directional_60_GHz_communication_for_multi-Gigabit-per-second_Wi-Fi_Invited_Paper/links/561fd77b08aed8dd1940402a/IEEE-80211ad-directional-60-GHz-communication-for-multi-Gigabit-per-second-Wi-Fi-Invited-Paper.pdf (discussing characteristics of 802.11ad technologies, including directionality, low interference footprint, and high spatial reuse).
[25] *See* Letter from Edward A. Yorkgitis, Jr., Counsel to Infineon Tech. Am. Corp., to Marlene H. Dortch, Sec'y, FCC, in GN Docket No. 14-177, at 1-2 (filed June 23, 2021).
[26] *Id.*
[27] *Id.*

radar meeting the conditions required to cause cognizable losses in WiGig data rates . . . virtually non-existent."[28]

C. Operation of Low-Power Radars at Increased Power Levels in the 60 GHz Band Does Not Pose a Threat of Harmful Interference to the Earth Exploration-Satellite Service (EESS).

Google has also conducted a study to assess the potential impact of Soli sensors on passive sensors in the EESS, finding that the likelihood of harmful interference is negligible to non-existent.[29] The study concentrates on airborne use, because attenuation from ground to space adds more than 100 dB of atmospheric attenuation compared to airborne use and therefore ground activity is not a factor in interference to spaceborne sensors.[30] The analysis employed conservative assumptions to show that airborne uses of devices containing Soli sensors "protect existing EESS sensors with a margin of over 30 dB."[31] Key factors that contribute to the wide margin include the low maximum EIRP of a Soli device, low duty cycle of Soli emissions, low bandwidth overlap between the EESS sensor channel and sweep range of the Soli sensor, and atmospheric attenuation.[32] A worst-case analysis against future EESS sensors yielded a "likely interference margin of at least 22 dB using generic ITU-R Rec RS.2017 criteria."[33] The study concluded that "all interference margins would be increased by more than 11.6 dB (i.e., to more than 40 dB for known sensors and to more than 30 dB for the generic case)" when attenuation of airplane windows and the beam pattern of the Soli

[28] *Id.*
[29] *See* Andrew W. Clegg, PhD, *Compatibility Between Earth Exploration-Satellite Service Sensors and Airborne Use of Project Soli Devices at 57.5 to 63.5 GHz* (June 2018), included as Attachment G.
[30] *See id.* at 17, Fig. 10.
[31] *Id.* at 18.
[32] *Id.*
[33] *Id.*

sensor's emissions are taken into account.[34] As with the assessments of potential interference to WiGig operations in the 60 GHz band discussed above, Google's studies of the impact of Soli sensors on passive services have been borne out by the absence of real-world interference issues during actual operations.

D. Updates to the Commission's Rules Are Necessary to Promote Continued Development of New Unlicensed Technologies in the 60 GHz Band.

Google again commends the Commission for initiating this proceeding to modernize its 60 GHz technical rules. By and large, proposals in the *NPRM* strike the right balance in promoting innovative communications and radar applications, services, and devices using 60 GHz spectrum. The Commission should expeditiously adopt its proposed rules with only minor modifications as described below. Doing so would preserve reasonable coexistence between radars and field disturbance sensors and other users of 60 GHz spectrum, while resolving outstanding technical and policy issues that have impeded innovation under the 2016 *Spectrum Frontiers Order* and recent waivers.

1. The Commission should remove the SRIMS designation for motion-sensing mobile radars in favor of a general FDS device designation for fixed and mobile radars.

Google agrees with the *NPRM's* proposal "to permit fixed and mobile radars to operate in the 60 GHz band" and to eliminate the mandatory qualification of an "application as SRIMS to operate as a mobile radar" under Rule 15.255.[35] This usage-agnostic approach will enable a host of new and promising use cases, some of which are not SRIMS, such as those based on presence or detection. Furthermore, as

[34] *Id.*
[35] *See NPRM* ¶ 34.

the Commission acknowledges, its current approach has generated significant confusion about "which 60 GHz mobile and fixed radar applications should qualify under the SRIMS designation."[36] A usage-agnostic rule eliminates the need for the Commission to "make a bright-line determination for certain applications[,]" providing greater certainty and enhancing flexibility that fosters innovation.[37] Removal of the SRIMS designation prioritizes technical performance of *all* 60 GHz radar technologies, rather than putting the Commission in the position of favoring or disfavoring particular fixed and/or mobile applications.

2. Updated regulations should take an even-handed approach across unlicensed technologies in the 60 GHz band, while promoting clarity and global harmonization.

The Commission is prudent to base most of the proposed updates to its 60 GHz rules on ETSI standard EN 305 550. Over the seven years in which EN 305 550 has been in force, its "limits have been tested and deployed in other geographic regions with similar spectrum allocations."[38] Contrary to some assertions in the record,[39] EN 305 550's technical parameters are stable. As the Commission notes, when ETSI released an updated draft of the standard in 2017, no changes to the limits in the standard were recommended.[40] Google understands that no major revisions of EN 305 550 are currently on the table; rather, any foreseeable updates would be limited normative references and details about measurement conformance tests. For instance, since

[36] *See id*.
[37] *See id*.
[38] *See id.* ¶ 28.
[39] *See* Letter from Priscilla Delgado Argeris, Facebook, Inc., *et al.,* to Marlene Dortch, Sec'y, FCC, in ET Docket No. 21-264 at 1-2 (filed July 2, 2021).
[40] *See NPRM* ¶ 28.

2019,[41] PSD is no longer a requirement in the radio regulation, and Google understands that a future version of the standard will reflect this. In short, there is no reason for the Commission to delay in adopting the ETSI-harmonized rule changes proposed in the *NPRM*, with the minor modifications discussed below. Like EN 305 550 itself, these updates would cultivate conditions that support robust sharing of 60 GHz frequencies across various users, while promoting the Commission's policy goal of global harmonization.[42]

Below, we address specific elements of the *NPRM*'s proposed rules.

The Commission Should Adopt Its Proposed Average EIRP Limit of 20 dBm. The Commission should adopt its proposal to allow FDS devices to operate at a 20 dBm average EIRP, which is consistent with ETSI EN 305 550.[43] This EIRP level encourages

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[41] *Comm'n Implementing Decision (EU) 2019/1345 of 2 Aug. 2019 Amending Decision 2006/771/EC Updating Harmonised Technical Conditions in the Area of Radio Spectrum Use for Short-range Devices*, 2019 O.J. (L 212) at Annex, Table 2, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D1345&from=EN (*EU 2019 Implementing Decision)* (setting an implementation deadline of January 1, 2020, for Member States to set limits of 100 mW EIRP and maximum transmit power of 10 dBm for non-specific short-range devices; no PSD limit is included).

[42] *See NPRM* ¶ 24 (noting the Commission's belief that "harmonization with other regions will likely increase efficiency for American manufacturers by reducing design and manufacturing costs"). *See also In the Matter of Facilitating Shared Use in the 3100-3550 MHz Band*, Second Report and Order, Order on Reconsideration, and Order of Proposed Modification, 36 FCC Rcd. 598, ¶ 18 (2021) (explaining that action "will harmonize the Commission's allocation for the 3.45 GHz band with international allocations"); *In the Matter of Amendment of Part 90 of the Comm'n's Rules*, Sixth Report and Order and Seventh Further Notice of Proposed Rulemaking, 36 FCC Rcd. 1958, ¶ 15 (2020) (observing that "successful international harmonization efforts could provide further advantages in the availability and price of equipment, thus potentially increasing its utility for flexible use"); *In the Matter of Promoting Spectrum Access for Wireless Microphone Operations, et al.*, Order on Reconsideration and Further Notice of Proposed Rulemaking, 32 FCC Rcd. 6077, ¶ 13 (2017) (revising a rule to reflect ETSI spurious emission limits to harmonize with the standards that applied to an industry in other countries) (*Wireless Microphone Order*); *In the Matter of Amendment of Part 15 of the Comm'n's Rules to Establish Regulations for Tank Level Probing Radars in the Frequency Band 77-81 GHz, et al.,* Report and Order and Order, 29 FCC Rcd. 761, ¶ 44 (2014) (noting that harmonizing emission limits with the ETSI limits serves to expand global marketing opportunities for U.S. manufacturers).

[43] *See NPRM* ¶ 24.

continued development of new FDS applications, and yields important design and manufacturing efficiencies by harmonizing regulations across regions.[44] Adoption of an average EIRP constraint as opposed to the peak EIRP constraints in current Commission regulations and recent waivers also would provide flexibility to accommodate different types of radar, such as FMCW and pulsed radars. In particular, a regulation based on average EIRP would allow radar designers to trade off instantaneous power with transmission duration to fit different use cases.[45]

As discussed above, a 20 dBm average EIRP limit will not pose the risk of harmful interference to other services in the band. As the Commission acknowledges, low-power 60 GHz radars "will operate at a comparatively much lower EIRP level" than the +40 dBm limit already in effect for communication devices in the 60 GHz band.[46] The characteristics of 60 GHz spectrum, such as high propagation loss, further mitigate interference risks. Google's 2018 study of Soli/WiGig interaction (Attachment E hereto) included simulations of a Soli radar operating without duty-cycling; even in that scenario, *de minimis* or minimal potential impacts to WiGig technologies were found.[47]

The Commission Should Adopt Its Proposed Frequency Range of 57-64 GHz for FDS Operations. Google supports limiting operating frequencies for FDS devices to 57-64 GHz, consistent with the EN 305 550 standard.[48] This would reserve the upper 7 GHz of the band for future potential use cases. It should be noted that, while this

[44] *See id*.
[45] Consistent with Rule 15.35(c), such averages should be computed over one complete pulse train. In this way, average metrics accurately capture the effect of any pulsing or duty-cycling (e.g., average power can be held constant by reducing duty cycle and proportionally increasing instantaneous power). 47 C.F.R. § 15.35(c).
[46] *See id.* § 15.255(c)(1)(i)*; NPRM* ¶ 24.
[47] *See Mangold Feb. 2018 Study* at 1.
[48] *See NPRM* ¶ 21.

proposal represents a reasonable compromise between competing interests, access to spectrum between 64 and 71 GHz would allow bandwidths of up to 14 GHz, which could potentially benefit 60 GHz radar technologies by enabling even finer spatial resolution.

Imposition of Transmitter Conducted Output Power and Antenna Gain Limits Would Be Superfluous. The transmitter conducted output power limits proposed in the *NPRM* should not be adopted, because—due to radar's significantly lower EIRP limits as well as lossy propagation at 60 GHz—adoption of the Commission's proposed EIRP limit alone would foster reasonable coexistence among unlicensed technologies using the 60 GHz band.

Should the Commission nevertheless deem it necessary to impose a conducted power limit, it should be an average conducted power limit of 10 dBm as in ETSI EN 305 550 and not a peak limit. An average limit would align with European regulations, promoting global harmonization, and provide radars with flexibility to utilize an average EIRP of 20 dBm. A peak conducted power limit, on the other hand, would largely eliminate the benefits of establishing an average EIRP limit of 20 dBm and erase potential beneficial uses of 60 GHz radar. Many radar applications are likely to utilize relatively wide beam antennas, with antenna gain of less than 10 dBi, to engage in sensing activities. If a 10 dBm transmitter peak conducted power limit was imposed, a system with antenna gain of 6 dBi would be limited to a peak EIRP of 16 dBm. If such a system utilized a hypothetical 20% duty cycle, the maximum average EIRP for the radar system would only equal 9 dBm—well below the 20 dBm proposed by the Commission.

The Commission also should decline to impose an antenna gain limit,[49] relying instead on its proposed EIRP limit. Codifying a maximum antenna gain would unnecessarily preclude the operation of radars using very narrow beam antennas, without any real benefit. Subjecting these radars to an EIRP limit will yield the same type of coexistence protections without introducing unnecessary measurement complexities or performance constraints.

A PSD Limit Is Unnecessary. The Commission should decline to adopt its proposed PSD limit.[50] Current European Union regulations do not include a PSD limit for 60 GHz non-specific short-range devices.[51] In addition to undermining global harmonization, imposing such a limit in the U.S. would incentivize radars to always use all available bandwidth, simply to maximize permitted power. While many radar use cases indeed require the full 7 GHz of bandwidth for optimal spatial resolution, narrower bandwidths are preferred for other use cases. Such radars should be permitted to operate with full power even when utilizing a subset of spectrum in the 60 GHz band, with the additional benefit that partial band usage enables frequency domain coexistence. Thus, imposing a PSD limit would not alleviate—and may even create—coexistence issues in the 60 GHz band.

Imposing a Duty Cycle Limit on 60 GHz Radar Operations is Unnecessary. There is no need for the Commission to place a duty cycle restriction on 60 GHz radar operations.[52] The EN 305 550 standard does not stipulate a duty cycle limit for 60 GHz short-range devices, instead taking an even-handed approach across technologies

[49] *See id.* ¶ 26.
[50] *See id.* ¶ 27.
[51] *See EU 2019 Implementing Decision* Annex, Table 2.
[52] *See NPRM* ¶ 30.

(including different varieties of radars) by imposing an average power constraint. While some products have been launched that operate in accord with the maximum 10% duty cycle stipulated in the Commission's 60 GHz waivers, this constraint results in considerable limitations to radar technologies. As a result of these duty cycle limitations, some potential use cases, such as micro-gesture control of devices beyond arms' reach or multi-person activity recognition at room-scale distances, are eliminated due to degradation in technical parameters, such as loss of range due to signal-to-noise ratio and reduced ability to discriminate targets moving at similar velocities.[53]

If the Commission does adopt a duty cycle limitation (which it should not), that restriction must be grounded in record evidence. For instance, the Commission should decline certain parties' notion to adopt a duty cycle requirement that "any radar off-time period between two successive radar pulses that is less than 2 ms shall be considered 'on time' for purposes of computing the duty cycle."[54] Such a rule would impose a fundamental limit on radar's ability to determine object velocity (i.e., the finest resolvable velocity is inversely proportional to both the pulse repetition period and the number of pulses transmitted),[55] which is entirely unnecessary due to radars' low transmission power and low potential to generate interference, as well as the propagation characteristics of the 60 GHz band. A pulse repetition period of 2 ms allows velocity

[53] The average power form of the radar equation shows that signal-to-noise ratio for a given target and distance is directly proportional to the transmitted power and duty cycle, and signal-to-noise ratio determines probabilities of detection and false alarm. *See* Mark Andrews Richards, *et al*., Principles of Modern Radar: Basic Principles 73-74, 95-103 (2010).
[54] *See* Letter from Alan Norman, Dir., Public Policy, Facebook, Carlos Cordiero, CTO, Wireless, Intel, and John Kuzin, Vice President & Regulatory Counsel, Qualcomm, to Marlene Dortch, Sec'y, FCC, in GN Docket No. 14-177 & ET Docket Nos. 21-48, et al., at 2 (filed May 10, 2021) (*FB/Intel/QC Letter*).
[55] *See* Mark Andrews Richards, *et al*., *supra* n.53 at 283-285.

estimation only up to 0.625 m/sec, which is less than even typical walking speed (1.5 m/sec) and is entirely insufficient for gestures that can have velocities greater than 5.0 m/sec. As explained later, this 2 ms off condition is incompatible with existing 60 GHz radar products.

Further, if the Commission deems that a duty cycle limit is absolutely necessary, such limit should apply only to radars that occupy a bandwidth greater than 4.5 GHz. A radar that has a bandwidth of less than 4.5 GHz can be aligned with two, 2.16 GHz-wide WiGig channels, leaving one WiGig channel completely free. With this approach, a communication system in an improbable situation of receiving significant interference from a nearby radar could completely avoid the radar in the frequency domain (i.e., avoiding frequency/channel). Additionally, consistent with the explanation below, a proposed time-off constraint would frustrate rather than promote reasonable coexistence. Thus, any duty cycle restriction should be set forth as a pure transmission duty cycle without an artificial restriction on what constitutes off-time.

Radars Should Be Allowed Optionally to Adopt a Listen-Before-Talk (LBT) or Sensing Mechanism and to Operate at the Same Power Levels as Communication Devices. The Commission should allow radars that incorporate LBT or other effective sensing technologies (i.e., techniques where radars periodically sense the channel for other nearby users, and operate accordingly) to operate at the same emission limits as communications devices in the band (i.e., 40 dBm EIRP and 27 dBm transmitter conducted output power).[56] Inclusion of an LBT/sensing mechanism should be *optional* for low-power radar technologies, because a mandate would generate unjustified costs

[56] *NPRM* ¶ 38.

and complexity. As explained above, 60 GHz radars without LBT/sensing already can harmoniously coexist with communication systems due to their lower powers as well as the propagation characteristics of the 60 GHz band. Nevertheless, adding an LBT/sensing *option* would enable higher power radar operation (for applications that deem it necessary) while also providing an additional, exceptional layer of protection to nearby communications systems.

II. UPDATED RULES SHOULD PROMOTE THE PRINCIPLE OF REASONABLE COEXISTENCE.

60 GHz WiGig and radar stakeholders alike[57] have voiced support for the Commission's objective of "ensuring coexistence among unlicensed FDS devices and current and future unlicensed communications devices in the 60 GHz band."[58] Google agrees that a "long-term regulatory solution is needed to allow for continued technological innovation while ensuring reasonable coexistence of all technologies operating under FCC Rule Section 15.255."[59] Accordingly, proposals to adopt rules aimed at theoretical concerns, for example with regard to possible latency-sensitive AR/VR/XR offerings opting to use 60 GHz band frequencies,[60] should be considered in view of their impacts on real operations of radars and other existing technologies using

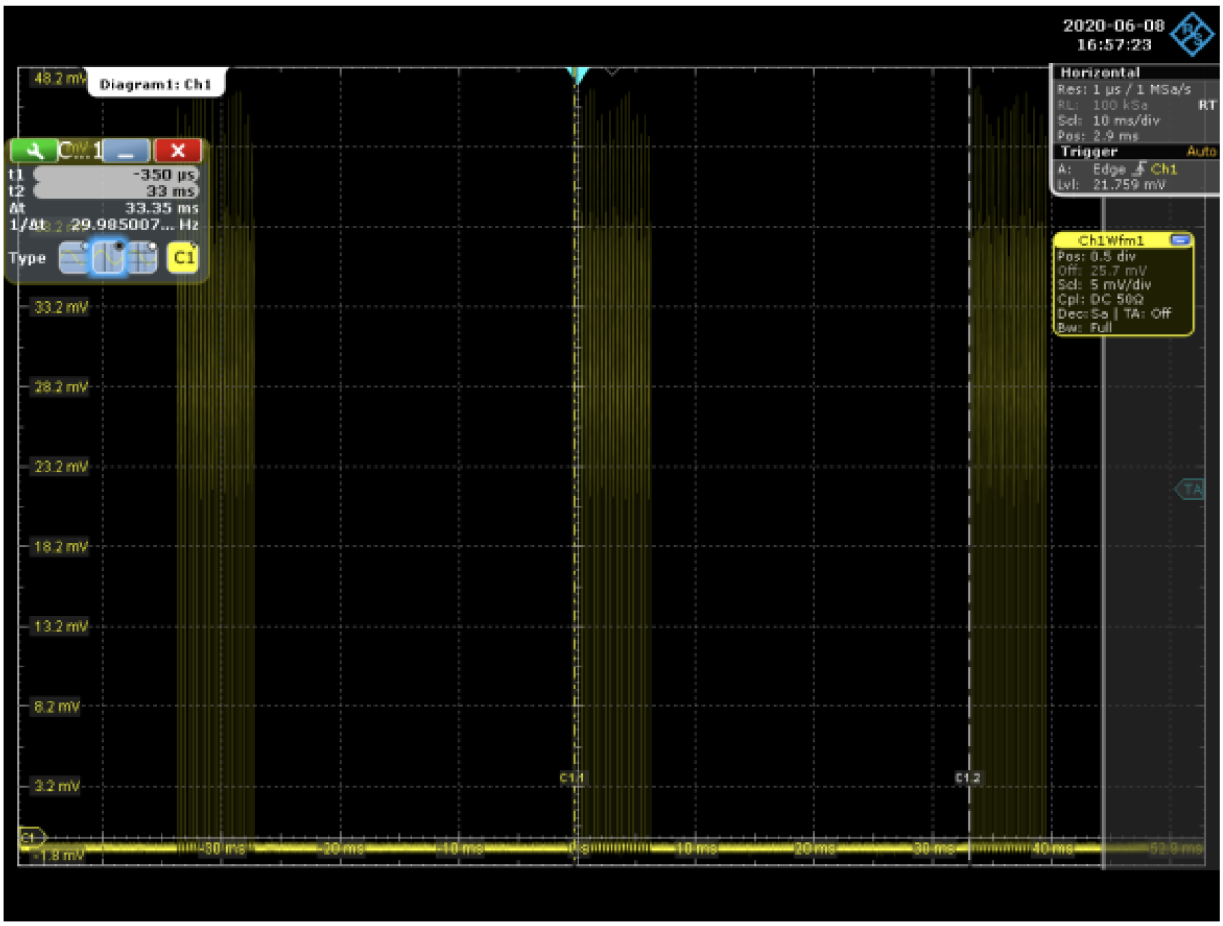
[57] *See, e.g.,* Letter from Acconeer AB, *et al.* to Marlene H. Dortch, Sec'y, FCC, in GN Docket No. 14-177 & ET Docket Nos. 21-48, *et al.*, at 1 (filed June 17, 2021) (in which the 60 GHz Coexistence Study Group (Acconeer AB, Continental Automotive GmbH, Facebook, Inc., Google LLC, IEE Sensing Inc., Infineon Technologies, Intel Corporation, Qualcomm Incorporated, Peraso Technologies, Inc., Samsung Electronics America, Socionext America, Texas Instruments, Inc., and Vayyar Imaging Ltd.) "agree that amendment of the FCC's technical rules is needed to allow for technological innovation while ensuring reasonable coexistence of various unlicensed technologies operating in 60 GHz frequencies.").
[58] *NPRM* ¶ 1.
[59] *See* Letter from Priscilla Delgado Argeris, Public Policy Manager, Facebook, Inc., to Marlene H. Dortch, Sec'y, FCC, in GN Docket No. 14-177 & ET Docket Nos. 21-48, *et al.*, at 2 (filed May 12, 2021).
[60] *See FB/Intel/QC Letter* at 3-4.

the spectrum. In any event, Commission regulations should not extend levels of protection generally reserved for licensed services to unlicensed WiGig technology, which is expected to share spectrum with other unlicensed technologies on a reasonable coexistence basis.

A key example is the misguided recommendation to modify the duty cycle restrictions in various Commission waiver orders to require that, for duty cycle computations, radar off-time between two successive radar pulses of less than 2 ms must "be considered 'on time.'"[61] Presentations to the Commission by Facebook, Qualcomm, and Intel indicate that this condition was designed to guarantee that at least 99% of WiGig packets experience on-air latency of no more than a few milliseconds.[62] This level of protection is reserved for licensed—not shared—use cases.

The proposed condition would have a profoundly negative effect on low-power 60 GHz radars. A review of the radar pattern for Google's Nest Home Hub provides an example. The Nest Hub uses Google's Soli technology and was certified by the Commission with a 7.9% duty cycle with 130.8 µs chirp width, which corresponds to 2.616 ms on-time (over 20 chirps) in any 33 ms observation period:[63]

[61] *See id.* at 3; *NPRM* ¶ 31.
[62] *See FB/Intel/QC Letter* at Attachment, slide 6 (stating that "[w]ireless link 99% packet latency has to be within [a] few milliseconds").
[63] *See* FCC Radio Test Report for FCC ID A4RGUIK2, at 10 (July 15, 2020), *available at* https://apps.fcc.gov/oetcf/eas/reports/ViewExhibitReport.cfm?mode=Exhibits&RequestTimeout=500&calledFromFrame=N&application_id=47okHTOCvgwaQoBKmNYqVg%3D%3D&fcc_id=A4RGUIK2.



Google Nest Home Hub Radar Pattern

The above signal capture shows three 33-ms radar periods. In each period, the radar sends a sequence of 20 chirps, one every 330 microseconds (equal to a 130 microsecond chirp followed by a 200 microsecond gap). These 20 chirps span a total of 6.6 ms, after which the radar is completely silent for the remaining 26.4 ms of the 33-ms period.

The “2 ms off” condition would incorrectly characterize this radar’s operation by deeming the above pattern incompatible with the 10% duty cycle limit in *Soli Waiver*

Order.[64] The actual transmission duration per 33 ms period for the Nest Home Hub is 2.616 ms, which corresponds to a 7.9% duty cycle. However, the 2 ms condition mischaracterizes the "on" time as 6.6 ms —the duration of the 20 chirps plus the gaps between those chirps—because the gaps between chirps are less than 2 ms. This would artificially and incorrectly boost the duty cycle to 20%.

The 200 microseconds gaps between chirps in the above example are, in fact, fully usable by other technologies, including WiGig. A WiGig frame containing five Transmission Control Protocol frames (each 1500B) sent at 4.62 Gbps[65] is less than 20 microseconds in duration (including the WiGig preamble) — a full order of magnitude smaller than the inter-chirp gap. Put another way, a WiGig system operating at 4.62 Gbps can transfer nearly a megabyte of data within 200 microseconds. It thus is inaccurate to characterize these inter-chirp times as "occupied" by the radar system.

In sum, regulatory guarantees of unlicensed-device latency targets like the one proposed by Facebook, Qualcomm, and Intel would substantially degrade performance of Frequency-Modulated Continuous Wave radars, which generally need to transmit chirps that are sufficiently frequent to measure high velocities and span a sufficient burst time to enable good velocity resolution. As noted above, restricting radars in this way also would be superfluous due to radars' low potential to generate interference due to

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[64] *See Soli Waiver Order* ¶14.

[65] 4.62 Gbps corresponds to the data rate of the highest single-carrier modulation data rate (MCS 12) in IEEE 802.11ad. The newer version of the standard – 802.11ay – supports higher data rates. *See* Rohde & Schwarz, *802.11ad - WLAN at 60 GHz A Technology Introduction: White Paper* 11 (Nov. 2017), https://scdn.rohde-schwarz.com/ur/pws/dl_downloads/dl_application/application_notes/1ma220/1MA220_3e_WLAN_11ad_WP.pdf; RF Wireless World, *802.11ad vs 802.11ay-Difference between 802.11ad and 802.11ay*, https://www.rfwireless-world.com/Terminology/WLAN-802-11ad-versus-802-11ay.html (last visited Sept. 20, 2021).

its low transmission power and the natural propagation loss in the 60 GHz band. Rather than tipping the scales toward 60 GHz communications technologies and against radar technologies, updated Commission rules should promote reasonable coexistence and maximize the complement of 60 GHz use cases beneficial to the public's interest.

III. THE COMMISSION SHOULD RETAIN ITS RULE FOR NARROW OPERATING BANDWIDTH FIXED RADARS AS DESCRIBED IN THE *NPRM*.

Google agrees with the Commission's assessment of the usefulness of Rule 15.255(c)(2) in permitting the "operation of fixed FDS devices at power levels as high as communication devices, albeit restricted to a more narrow operating bandwidth, without being restricted to a specific duty cycle limit."[66] Google's Nest Thermostat uses Soli sensors calibrated to comply with this existing provision to detect occupancy and to light up the display when someone is near the device, which results in meaningful energy savings by adjusting heating and cooling cycles based on when people are actually home.[67] The Commission should thus retain this rule, which offers additional flexibility for development of fixed radars that can "achieve better resolution with a wider bandwidth."[68] Furthermore, if the Commission were to adopt the regulatory updates proposed herein, the Nest Thermostat and similar technologies would enjoy an enhanced signal-to-noise ratio, which would allow the radar technology to more accurately generate occupancy estimates that enable energy saving features.

Google also supports interpreting "fixed FDS operations as those instances where an FDS device is stationary and is operating at a discrete location for an

[66] *NPRM* ¶ 35.
[67] *See* Google Nest Help, *Sensors in Google Nest Devices*, *at* https://support.google.com/googlenest/answer/9330256 (last visited Sept. 20, 2021).
[68] *NPRM* ¶ 35.

indefinite – *i.e.*, more than mere transitory – period."[69] This clarification of Rule 15.255(c)(2) would support innovation in an important category of devices. For instance, many smart devices used within households, such as speakers or Home Hubs with video screens, are portable but typically are plugged in or otherwise stay in the same location while in use. These mostly stationary devices pose no greater risk of harmful interference than fixed 60 GHz communications or radar devices operating at the same power levels. This interpretation of "fixed" advances the Commission's stated goal of "provid[ing] as expansive an opportunity for unlicensed operations in [the 60 GHz] band as is practical."[70]

IV. DEVICES MANUFACTURED PRIOR TO THE UPDATED RULES' EFFECTIVE DATE SHOULD BE ALLOWED IN COMPLIANCE WITH ANY WAIVERS UPON WHICH THEY RELY.

Devices reliant on the terms of the *Soli Waiver Order* and the Commission's other 60 GHz regulatory waiver orders have launched, and others are in the development pipeline. Users will expect these devices to continue to function seamlessly for the foreseeable future. New regulations, however, could in some cases require changes that would degrade sensor performance or entirely eliminate certain functionalities. Some devices in the field may not even be capable of being updated to meet new Commission regulations. The Commission accordingly should allow devices to continue to be sold and operated pursuant to the terms of their underlying waivers for their useful lives.[71]

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[69] *Id.* ¶ 37.
[70] *Id.*
[71] *See id.* ¶ 18 (noting that to the extent the 60 GHz rules are modified, the Commission would expect that "all future 60 GHz FDS operations would be conducted subject to our modified rules").

CONCLUSION

The Commission should swiftly update its rules for the 60 GHz band. Doing so will foster continued innovation by industry stakeholders, including those introducing transformational and potentially life-saving radar functionalities to consumers. Google supports the Commission's proposed regulatory framework, which substantially tracks ETSI standard EN 305 550. With the minor modifications described above, this approach would encourage reasonable coexistence across unlicensed communications and radar technologies throughout the 60 GHz band. While making these changes, however, the Commission should ensure that low-power 60 GHz radars currently in the market or production pipeline continue to be available, consistent with user expectations.

Respectfully submitted,

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